HOW-TO-GUIDE

Version 1.2

ST360 Quadrotor Frame Crius
AIOP V2 Flight Controller
MegaPirateNG 2.8R3 Firmware

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1 Wiring Guide

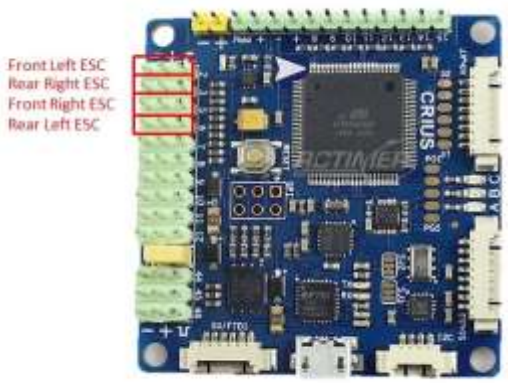

Figure 1: ESC connections to CRIUS AIOP V2

Figure 2: Receiver connections to CRIUS AIOP V2

2 Quadrotor Calibration

2.1 Transmitter and Receiver

The transmitter and receiver being used are the HK-T4A V2 model from Hobby King. This set also includes the binding plug which is used to connect the two together. This specific transmitter only has four channels which allow for the throttle, pitch, roll, and yaw to be used. If an additional channel is needed for using flight modes, a six channel equivalent exists from the same supplier.

2.1.1 Getting Started

The transmitter takes eight AA batteries in the back of the device to be powered. The left stick of the transmitter controls the throttle and yaw, while the right stick controls the pitch and roll as shown in Figure 3. One thing to note is the right stick will always return to its original position in the center, the left stick does not. This is to help aid in keeping the throttle a constant value.

Figure 3: HK-T4A Transmitter

2.1.2 Trim Control

The switches in the red circles in Figure 3 can be used to make adjustments for the roll, pitch, and yaw. These adjustments are used to counteract the drift of the quadrotor. Drift can be described as if there is a constant wind blowing across a specific axis. The switches need to be changed in a direction opposite of the drift. For example, if the quadrotor is rotating clockwise, the yaw trim needs to be moved to the left. Continue changing the trim on all four axis until stable flight is achieved.

2.1.3 Reverse Switches

The transmitter has 4 switches, highlighted in green in Figure 3, that allow the direction of the throttle, pitch, roll, and yaw to be reversed. For example, if the throttle switch was changed, zero throttle would be at the maximum position of the left stick. These will be configured later through Mission Planner.

1. THR → Throttle
2. AIL → Aileron → Roll
3. ELE → Elevator → Pitch
4. RUD → Rudder → Yaw

Figure 4: HK-T4A Receiver

2.1.4 Binding

The receiver can only take a voltage range of 4.8V - 6V to be powered. Follow these steps using the binding plug that was provided with the set along with an ESC and battery.

1. Insert the binding plug into the BAT slot on the receiver.
2. Plug in the ESC servo cable into CH3 on the receiver. Ensure that the ground wire is farthest right to prevent damage as seen in Figure 4.
3. Turn on the transmitter while holding down the Bind button on the transmitter. Keep holding the Bind button on the transmitter until the light stops blinking on the receiver module.
5. Unplug the bind plug on the receiver, and test with a servo.

2.2 Downloading and Installing Firmware

1. Download the MegaPirateNG 2.8 R3 firmware from https://code.google.com/p/megapirateng/downloads/detail?name=MegaPirateNG_2.8_R3.zip&can=2&q= and extract its contents onto the desktop.
2. Download and install the latest Arduino (v1.0.5) from http://arduino.cc/en/Main/Software#toc2.
3. Plug in the CRIUS AIOP V2 board via USB to automatically download the correct drivers.
4. Open the MegaPirateNG_2.8_R3 → libraries folder and copy its contents.
5. Place these files into the Local Disk(C:) → Program Files (x86) → Arduino → libraries folder of the Arduino files downloaded in step 2.
6. Open Arduino.
7. Go to Tools → Board and select Arduino Mega 2560 or Mega ADK
8. Go to Tools → Serial Port and select appropriate COM port.
9. Go to File → Open and choose the file MegaPirateNG_2.8_R3 → Arducopter → Arducopter.pde from the files downloaded in Step 1.
10. Select the tab labled APM_Config.h and verify that Line 7 reads #define PIRATES_SENSOR_BOARD PIRATES_CRIUS_AIO_PRO_V2
11. Click the Upload Arrow as seen in Figure 5 to upload the firmware onto the board.

Figure 5: Upload button for Arduino

12. No errors should occur and the firmware is ready to be calibrated.

Note: Make sure that no other Arduino versions exist on the PC or errors will occur.

Note: Verify the COM port by going to Device Manager and determining the XX of the USB Serial Port (COMXX) device.

Note: All file paths are based on the default locations.

2.3 Mission Planner

This software is used for all further calibration. These include calibrating the transmitter, PID, accelerometer, gyro, flight modes, etc. Be aware that there are many different version of Mission Planner, and all the buttons are not named the same. All of the information needed is in the same places as every other version though, just possibly a different name.

1. Download and install MissionPlanner (v1.2.95) from http://ardupilot.com/downloads/?did=82 and all of the drivers prompted.
2. Open the MissionPlanner-latest.msi file downloaded, click on Run and allow updates to complete.
3. Go to Local Disk(C:) → Program Files (x86) → Mission Planner → MissionPlanner and launch the application.
4. DO NOT allow the fist time Wizard to run, press No.
5. Connect the CRIUS AIOP V2 board via USB.
6. Click on the COM port drop down menu in the top right and change to AUTO.
7. Click the CONNECT button.
8. The board will connect after some time.

2.3.1 Radio Calibration

The transmitter uses the same pulse as a simple servo which ranges anywhere from 1000µs → 2000µs. This calibration shows the micro controller what range of pulses to expect from the transmitter so the appropriate actions can take place for flight.

1. Open Mission Planner.
2. Go to INITIAL SETUP → Mandatory Hardware and then click on Radio Calibration on the left.
3. Turn on the transmitter.
4. Click on the Calibrate button and press OK twice.
5. Move both sticks UP, DOWN, LEFT, and RIGHT.
6. The green bars will move and the red lines show the maximum and minimum values of the PWM signal.
7. Press Click when done and then OK when finished.

Note: If the directions are not what is expected, use the Reverse Switches on the transmitter to switch the direction

2.3.2 Frame Type Calibration

1. Go to INITIAL SETUP → Mandatory Hardware.
2. Click on Frame Type.
3. Choose the 'X','Y6A' radio button.

Note: This is the default, but check to ensure this is the case.

2.3.3 Level Calibration

1. Go to TERMINAL
2. Click Connect.
3. Type setup and press Enter.
4. Make sure the quadrotor is completely level on the table.
5. Type level and press Enter.
6. Wait several seconds for completion, then click on FLIGHT DATA
7. Click on CONNECT in the top right again.
8. Move the quad around and observe changes in the roll, pitch, and yaw.
9. Make sure the roll and pitch are actually level when lying flat.

2.3.4 Proportional Integral Derivative (PID) Tuning

A PID controller is used in control systems to monitor a process to determine the error in the system over time. This is a three part process, where: the proportional constant calculates the present error, the integral has the accumulation of past errors, and derivative contains the predicted error values. The PID constants we are changing are roll, pitch, yaw, throttle, and Altitude Hold. To modify these values, follow the steps below in Mission Planner.

1. Go to CONFIG/TUNING
2. Click on OK twice.
3. Click on Extended Tuning

Figure 6: PID Controller Constants in Mission Planner

4. Make sure the Lock Pitch and Roll Values is checked. This allows both pitch and roll to be tuned the same.
5. Tune only Rate Roll, Rate Pitch, and Rate Yaw, starting with the P constant.
6. Type 0.054 for the value of P for Rate Roll, Rate Pitch, andRate Yaw as seen in Figure 6.
7. Click on Write Params to upload the current values to the board.
8. Use Section 2.6 to perform a Test Flight then return to tune the drift.
9. Drift is tuned using the I constant in the Rate Roll, Rate Pitch, and Rate Yaw.
10. Adjust I constant to read 0.014 for Rate Roll and Rate Pitch.

11. Adjust I constant to read 0.02 for Rate Yaw.
12. Perform another Test Flight. The quad should be stable and have low drift during flight.
13. Additional tuning might be required. Continue these steps by adjusting constants in small increments and completing a test flight.

Note: DO NOT mess with any other PID constants!

Note: If a test flight is done before tuning, the quad will flip over and cause damage.

Hint: Oscillations will occur if the value of P are too large, decrease to compensate.

Hint: Drift will occur if the value of I is too large, decrease to compensate.

2.4 SAFE MODE

This mode is used for safety while using the quadrotor. The red LED on the CRIUS AIOP V2 always shows the status of SAFE MODE. If SAFE MODE is engaged, no signals are passed to the receiver and the red LED is solid, ready for flight.

1. To engage SAFE MODE; hold the throttle at zero, and yaw all the way left on the transmitter.
2. To disengage SAFE MODE; hold the throttle at zero, and yaw all the way right on the transmitter.

2.5 Electronic Speed Controller (ESCs)

Program each ESC individually to ensure proper calibration. Before starting this process make sure that the battery is unplugged and that no power goes to the board.

1. Remove all of the propellers to prevent lift off.
2. Turn on the transmitter and set throttle to its maximum value.
3. Plug one ESC servo cable into CH3 of the receiver.
4. Plug in the battery.
5. The ESC will beep twice, then quickly drop the throttle to zero. More beeps will sound showing a successful calibration.
6. Ensure ESCs work correctly by varying the throttle.
7. Repeat this process until all four motors are working properly.

2.6 Orientation

Its important to have the proper orientation of the quadrotor. This includes the actual frame type, types of propellers, and the direction of rotation of the motors. The yellow propellers are used to aid in determining the front of the quadrotor, and the arrow on the Crius AIOP V2 should reflect this.

Figure 7: Motor and Propeller Directions

2.6.1 Motor Directions

Each motor needs to spin in a specific direction to enable flight, like in Figure 7. The motor directions are defined by pairs of either clockwise or counter-clockwise directions. The process to determine and alter these directions is shown below.

1. The top left/bottom right motors rotate in the clockwise direction
2. The top right/bottom left motors rotate in the counter-clockwise direction.
3. Turn on the transmitter, making sure throttle is set to zero.
4. Plug in the battery.
5. Slowly increase throttle and analyze the rotation direction of the motors.
6. If the motors rotate in the wrong direction then complete steps 7-10.
7. Unplug two of the three wires connected to the motor.
8. Switch the two to allow the motor to rotate the opposite direction.
9. Test that the motor directions are correct.
10. Repeat process if needed for all motors.

2.6.2 Propellers

As shown in Figure 7, there are two types of propellers, regular and push. The push propellers are denoted by a 8045P on the face up side. Ensure that the correct propellers are on the correct motor before flight.

1. Front-Left → Push
2. Front-Right → Regular
3. Rear-Left → Regular
4. Rear-Right → Push

2.6.3 Attaching Propellers

Attaching the propellers is a simple process.

1. Unscrew the tops of the motor.
2. Place correct propeller on the motor.
3. Screw the top of the motor back on tight.

Note: Sometimes it is easier to use the propeller for leverage to tighten them down.

2.7 Test Flight

It is highly recommended that a test flight is completed after additional tuning is made to the quadrotor. Many test flights are essential in leaning how the quad flies in various scenarios.

1. Turn on the transmitter. Make sure that the throttle is at zero!
2. Place quadrotor on the ground a safe distance away from yourself and other people.
3. Plug in the battery and step back.
4. Disengage SAFE MODE. The quadrotor is now live and will move when the throttle is increased.
5. Slowly increase throttle and try her out. BE CAREFUL!
6. When test flight is complete, land the quadrotor gently by slowly decreasing the throttle.
7. Engage SAFE MODE so nothing can cause harm to you.
8. Unplug the battery.
9. Turn off the transmitter.
10. Continue to repeat process until comfortable with flight or changes need to be made.

Tip: When flying, stand behind the quadrotor for safety. The yellow propellers are the front and should be facing away from you.

Tip: Turn off the transmitter last so no random signals are passed.

Tip: Fly the quad low to the ground during first flight, almost on the ground while trying out the roll, pitch, and yaw.

Tip: Make very small changes to the control sticks on the transmitter.

Tip: Never get cocky when flying, this leads to damaging hardware. No matter how experienced you are, always respect the danger the quadrotor is capable of.

Tip: The quadrotor will start to lose altitude at lower battery levels with the same amount of throttle.

2.8 Flight Modes

Thirteen different flight modes exist, but we only need to use two of them, Stabilize and Altitude Hold. Stabilize mode is used during normal operation to ensure stable flight is achieved. Altitude Hold mode makes use of the CRIUS AIOP V2 barometer sensor to hold a specific altitude that is dependent on the current throttle. Six different modes can be programmed at one time using Mission Planner as seen in Figure 8. Follow steps below to change the Flight Modes.

All Flight Modes are split up onto one channel of the transmitter. The ranges of PWM signals can be seen in Figure 8. This can not be done using our HK-T4A transmitter because we need a fifth channel for control of flight modes. A micro-controller is used to enable this fifth channel to the CRIUS AIOP V2 flight controller. A specific PWN pulse in the correct range, as programmed in Mission Planner, can be used to enable other modes.

Simple Mode can be checked to alter flight. Currently the yellow propellers show the front of the quadrotor, and this will always be forward, regardless of the orientation. In simple mode, the orientation does not matter. The launch position will determine forward and will never change.

Figure 8: Flight Modes Tab in Mission Planner

1. Go to INITIAL SETUP → Mandatory Hardware.
2. Click on Flight Modes.
3. Click the drop down menu and choose the desired flight mode from the list.
4. Press Save Modes.

Note: To make the flight modes work, the specific range of pulse needs to be sent from the receiver to the AUX1 Pin of the CRIUS AIOP V2.

2.8.1 Altitude Hold

When properly calibrated, a specific altitude can be kept in this mode. This can be further advanced to wait for a specific height from the input of sonar until switching modes. Altitude Hold mode works by keeping the throttle at a constant value, using the throttle level when engaged as its base. A dead zone is enforced on the transmitter to allow for some fluctuation in the throttle. This mode can be switched on a off when needed by sending the appropriate PWM signal.

1. Go to INITIAL SETUP → Mandatory Hardware.
2. Click on Flight Modes.
3. Click the drop down menu and choose Altitude Hold for Flight Mode 2.
4. Press Save Modes.
5. Perform a Test Flight.
6. Fly to an appropriate altitude, and hold the throttle steady.
7. Apply a PWM signal between 1231 - 1360 to the AUX1 Pin to enter Altitude Hold mode.
8. DO NOT touch the throttle anymore. The altitude will stay steady at the current throttle. The roll, pitch, and yaw can still be used to control the quad.
9. Apply any other PWM signal not in the range of 1231 - 1360 to return back to Stabilize mode.
10. Land safely and turn off per instructions in Test Flight.

2.8.2 Sonar

The barometer can be extremely unreliable for low altitudes. An ultrasonic (sonar) sensor can be used instead to allow for reliable distance measurements. The XL-Maxsonar-EZ4 sensor from Maxbotix will be used for the sonar due to the narrow beam and longer range. Multiple different outputs (PWM, analog, and RS232 formats) can be achieved simultaneously.

The CIUS AIOP V2 flight controller has two pins, Trigger and Echo, located on pins 9 and 10. They are used for connecting a sonar sensor to aid in Altitude Hold mode. The pins are located on the same rail as the motor ESCs, and are denoted with a T and E on the back side. Power and ground can also be connected on the ESC rail.

1. Go to TERMINAL.
2. Click Connect.
3. Type setup and press Enter.
4. Type sonar0 and press Enter to choose the specific sensor being used.
5. Click on Tests near the top.
6. Type sonar and press Enter.
7. Use the wiring guide for the sonar in Figure 9 before testing.

Figure 9: Wiring Guide for Sonar to CRIUS AIOP V2

8. Distance measurements will show if connected properly. Press Enter to stop the data.

Note: The battery must be plugged in to allow power to flow to the ultrasonic sensor. Make sure the battery is plugged in before the USB cable.

Note: The max range to use the sonar can be change in the APM_Config.h file under #define MAX_SONAR_RANGE 400.

3 Battery

The batteries being used are Lithium-Polymer (Li-Po) with three cells. They have a voltage of 11.1 V and a current of 2.2 A. These batteries are extremely dangerous and can explode. Always check for any damage after use and then store inside the LIPO-SAFE protection bag while not using. Make sure to be near the batteries when charging.

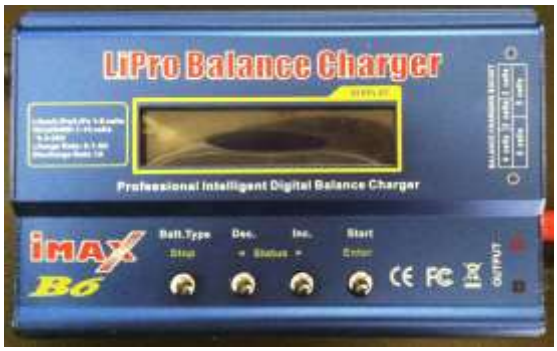

Figure 10: LiPo Battery Charger

3.1 Charging

1. Plug the battery into the LiPro Balance Charger charger seen in Figure 10.
2. Turn on the BK-PRECISION 1902 power supply and set to 14 V.
3. Connect the positive and negative terminals to the battery charger.
4. Click on the Batt. Type button and arrow over to LiPo BATT.
5. Press Enter then right arrow until 2.2A to set up the current.
6. Press Enter then right arrow until 11.1(3S) to set up the voltage level.
7. Hold Enter until a loud beep sounds.
8. Press Enter again to confirm charge.
9. Wait until the alarm sounds for a full charge.

Note: You can press the Stop button at any time to cancel or go back.

4 Bill of Materials (BOM)

Consult the Quad_BOM excel file in the Google Drive.

5 Suggestions and Improvements

COMING SOON!

6 Autonomy

COMING SOON!